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The Tropical Rainforest Market Failure: An Argument for the Pursuance of Compensation for Conservation Policy

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Abstract:

Ecosystems provide great benefit to society and economies throughout the world. Unfortunately, due to their nature as public goods, markets related to their supply often see failure. The conservation of many of these ecosystems is vital to the health of the planet, humanity and the economy. The goods and services ecosystems provide are not restricted by border. As developed countries take stronger roles by investing in conservation and environmental production within their own borders, developing countries struggle to follow their example. The main reason for this is their diminished ability to pay for such conservation. Their short-term needs, such as poverty reduction, tend to overshadow long-term needs, such as conserving a sustainable environment. Therefore it is necessary that developed countries compensate developing countries for the conservation of ecosystems of which they receive the greatest benefit.

I. Introduction

Every economy is built upon various forms of capital. These include built, human, social and natural capitals. It is interesting however that natural capital is often the most misunderstood in traditional economics. The value of all of the goods and services we receive from the environment is grossly underappreciated in typical economic behavior. People, in many cases, fail to perceive the true value of these goods and then free-ride off of the current services offered by ecosystems such as tropical forests. This is particularly the case in developing countries that are unable to pay for the conservation of these rich ecosystems. The value of these goods and services is also underappreciated in terms of other markets to which these ecosystem services are related.

For example, the timber industry often disregards the ecological impact tree harvesting has, due to a lack of incentive. When tropical forest land use is subject to behavior such as timber development, it is usually because forest owners receive little to no compensation for the services these forests generate[1]. Nevertheless, in many cases the costs of harvesting the trees of a forest outweigh the benefits thereof. Our goal in the case of conservation is sustainability, which Voinov and Farley describe as "the goal of keeping something at a certain level, of avoiding decline."[2] Maintaining the optimum level of "ecosystem services" is vital to the survival of humanity as many of these services provide a basis for life itself.

Ecosystem services carry the characteristics of public goods. As a result, they must be treated as such. Also, markets related to marketable products associated with the exploitation of tropical forests[3] (what we will call forest products) result in externalities that must be addressed. Examples of forest products include timber, land, agricultural products, oil, etc. Both of these market failures can be resolved through methods that allow for compensation in return for conservation of vital ecosystems. *As conservation is a difficult objective for developing countries struggling to become economically competitive it is necessary that developed countries pay for the benefit they receive from these ecosystem services provided by tropical forests in return for their conservation.*

The next section will explain the characteristics of ecosystem services as well as a brief history of economic thought concerning their role in the economies of the world.

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[1] Nahuelhual, Laura, Pablo Donoso, Antonio Lara, Daisy Núñez, Carlos Oyarzún and Eduardo Neira "Valuing Ecosystem Services of Chilean Temperate Rainforests," *Environment, Development and Sustainability*. Vol. 9, No. 4 (November 2007), pp. 495

[2] Voinov, Alexey and Joshua Farley. "Reconciling Sustainability, Systems Theory and Discounting." *Ecological Economics*, Vol. 63, No. 1 (June 2007), pp. 106

[3] Unlike ecosystem services, marketable products associated with the exploitation of tropical forests have a defined value on the commodities market. We will simplify this term to "forest products" from here on.

Section three will provide a look at the two types of market failure involved with this suboptimum level of conservation, as well as consider an optimum level of conservation. Section four will include a short discussion regarding an Ecuadorian case-study in which a block of the Amazon Forest is considered. Section five will display a wide array of policy suggestions that accomplish the difficult goal of paying developing countries for the conservation of their forests. Lastly, section six will conclude.

II. Ecosystem Services

Simply defined, ecosystem services are the goods and services generated from the natural processes and components of any given ecosystem.[4] While the term “ecosystem services” is representative of both goods and services it has been traditionally shortened for the sake of simplicity.[5]

In 1998 an article titled “The value of the world’s ecosystem services and natural capital” by Roberts Costanza, et al., became a seminal piece of work in the world of ecological economics. In this article Costanza, et al., claim that the global economy would be significantly different today if ecosystem services were paid for.[6] This means that “the price of commodities using ecosystem services directly or indirectly would be much greater.”[7] Encompassing all of these good and services into the global economy would undoubtedly reshape its structure.[8] In evaluating such services Costanza, et al.,

[4] Nahuelhual, et al. 484
[5] Costanza, Robert, et. al “The Value of the World’s Ecosystem Services and Natural Capital,” *Ecological Economics*. Vol. 25, No. 1 (April 1998), pp. 3-15
[6] Costanza, et al. 14
[7] Id. 14
[8] Kaiser, Brooks and James Roumasset. “Valuing Indirect Ecosystem Services; The Case of Tropical Watersheds.” *Environment and Development Economics*. Vol. 7, No. 4 (October 2002); pp. 701-714

suggests a global annual value between US$16-54 trillion[9] with an estimated average of approximately US$33 trillion for ecosystem services as of 1998. These figures represent a dollar amount 1.8 times the global GNP in 1998.[10] This robust number certainly requires that society as well as most economists reconsider the value of nearly every product throughout the global economy. Even if this figure is only half right it is clear that we must begin to consider ecosystem services as a contributor to our social and economic well-being.

One of the main reasons for this undervaluation of ecosystem services pertains to the lack of information society possesses regarding their actual value. There are many that argue the feasibility of evaluating such services, but we do so each and every day.[11] Many insurance companies make their business based on the idea that intangible goods, such as ecosystem services, (human life, etc.) can be evaluated at some price level. Barbier acknowledges that "our knowledge of the ecological functions, let alone the ecosystem processes and components underlying many (services) is still incomplete."[12]

Today there are twenty-three recognized ecosystem services (see Appendix 1).[13] It may be easier to consider this topic by looking at one specific ecosystem service. Carbon sequestration[14] is certainly one of the most covered ecosystem services in modern politics and media. Trees have the capability to absorb some level of carbon dioxide, the

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[9] Note: The methods for finding such figures are in constant development. Two schools developing methods for assessing the monetary value of ecosystem services are the Gund Institute of Ecological Economics at the University of Vermont and Stanford University

[10] Costanza, et al. 14

[11] Id. 6

[12] Barbier, Edward B. "Valuing Ecosystem Services." *Economic Policy*. (January 2007); pp. 212

[13] Asia Pacific Environmental Exchange. <u>Ecosystem Services Enhanced by Salmon Habitat Conservation in the Green/Duwamish and Central Puget Sound Watershed</u>. Seattle, WA: Asia Pacific Environmental Exchange. (February 2005); pp.10-11

[14] <u>Carbon sequestration</u>: The storage of carbon dioxide over an extended period of time within plants, trees, the ground and the ocean, that results in a drop in its atmospheric levels.

most ubiquitous greenhouse gas, inhibiting much of its release into our atmosphere. The process of carbon sequestration, therefore, induces some degree of societal benefit. As a public good, however, this service is currently unmarketable due to a market failure, of which we will detail later. While this may be the case, it is economically realistic to expect beneficiaries to pay for this benefit as they should for a service in any given market.

Paying for said services, nevertheless, is relatively unreasonable at this point in time. The truth of the matter is that there is technically no current market for ecosystem services (though carbon sequestration has sometimes been linked to carbon credit systems[15]). The main cause for this problem is the non-excludable nature of ecosystem services. They bear the characteristics of a public good and as such are undervalued by the world's population. Unfortunately, ecosystem services carry all of the traits that suggest a public goods market failure with the potential for externalities in associated markets.

III. Market Failure

3.1 *Public Goods*

Pure public goods have two overarching properties, which Brown, et al.[16], describe as non-excludability[17] and jointness of supply[18]. Resulting from these

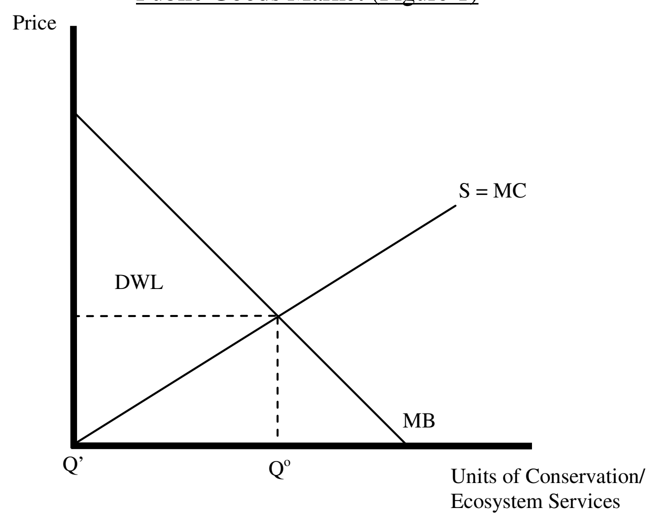
[15] A carbon credit system can be defined as a market that allows the trade of carbon dioxide permits, which then allow a certain level of released emissions. Some countries (i.e. Indonesia, etc.) suggest that carbon credits could be a way of compensating a forest owner for the conservation of their property. This idea will be discussed further along in the paper.

[16] Brown, Stephen N., David Price and Satish Raichur. "Public-Good Theory and Bargaining between Large and Small Countries." *International Studies Quarterly*. Vol. 20, No. 3 (September 1976); pp. 396.

[17] Brown, et al., claim that non-excludability is when one country consumes a good, and in doing so all other countries consume a similar amount of that same good

characteristics is a scenario referred to as free-riding. Nunn and Watkins describe this as when "self-interested members of a large group fail to engage in collectively profitable action."[19] This means that these particular members, of a community for example, have low to no willingness to pay for the benefit received from a public good. Since they are not faced with any kind of monetary fee for the use of this good they have little incentive to pay for it. As such, we are directed to a public goods model in which this dissociation between demand and marginal benefit, and the implications thereof, is revealed.

Public Goods Market (Figure 1)



Where MC=MB we have the optimum quantity Q^o. Without any form of demand the current quantity level is at Q'. The deadweight loss is reflected by DWL.

Looking at the Public Goods model (figure 1) we can see that at some level of conservation, Q', there is a gross underallocation of resources towards conservation. It should also be considered that each unit of conservation is also an increase in the supply of ecosystem services. It must first be noted that demand for ecosystem services doesn't exist in a marketable sense (or if it does it is practically non-existent). Demand may be reflected in minimal contemporary conservation efforts (typically through environmental or governmental organizations); however we will assume no demand in this model.

[18] Brown, et al., says that jointness of supply is when consumption of a specific good by a single country does not reduce its supply for another country.
[19] Nunn, Geoffrey E. and Thayer H. Watkins. "Public Goods Games." *Southern Economic Journal*. Vol. 45, No. 2. (Oct., 1978); pp. 598

To analyze this model and understand this lack of demand, let us first consider what makes up demand. Demand, of course, is the representation of ability and willingness to pay for a particular good or service. Interestingly, those who are able to consume the benefits of many of these ecosystem services are not restricted by border as they include citizens from countries all over the world.

The "willingness to pay" area of demand, as discussed, is subject to free-riding. This is a pervasive issue in a public goods market, as people consume ecosystem services without paying for them due to their non-excludable nature[20]. However, if governments were to represent their citizens, thereby paying for conservation on their behalf, it is likely that we would see a rise in the quantity of conservation demanded (and therefore an improved level of ecosystem services). When considering ecosystem services we must remember that they are not a commodity per se. We are not technically paying for the production of an additional unit of ecosystem services with every increased unit of Q; rather with each increase in Q we are *ensuring the conservation of at least that many units of ecosystem services*. In this, every unit of conservation is equal to some avoided reduction in ecosystem services.

When the "ability to pay" portion of demand is considered it should be understood that many developing countries are simply unable to comply with the goals of conservation. Sheeran makes the case that "preserving natural resources, though necessary for achieving sustainable economic development in the long run, is a costly strategy for developing countries where the overriding economic and social priority is

[20] Costanza, et al. 4

poverty alleviation."[21] Short-run priorities such as poverty reduction often take political priority over attempts to fix ills of the long-run. This can be somewhat attributed to the lack of a stable government in many of these countries where, as Didia puts it, "the government is… preoccupied with survival in office."[22] Without this concern political leaders are freer to pursue long-term goals of sustainability throughout their economy. As such, we can attribute some of this difference between demand and marginal benefit to a decreased "ability to pay" for conservation from developing countries.

These issues related to "ability and willingness to pay" help provide a background as to why demand falls short of marginal benefit in our public goods model. The deadweight loss associated with this underallocation of resources is represented by the triangle marked DWL. As stated earlier the "willingness to pay" issue can be solved when the government can assume the funding of conservation through compensating owners of ecosystems such as tropical forests. This allows for the elimination of free-riding on the part of individuals. To make certain that this issue doesn't take place on an international scale it may be that a supranational organization (such as the UN, World Bank, or another organization) takes control of compensatory tactics. We can also address the "ability to pay" situation through such a program. This would allow for developed countries to pay developing countries, which possess much of the world's forests, to conserve. Regulations such as these may allow for a greater contribution of resources towards conservation/ecosystem services, reflected in a demand closer aligned to the marginal benefit of such services.

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[21] Sheeran, Kristin A. "Forest Conservation in the Phillippines: A Cost-Effective Approach to Mitigating Climate Change?" *Ecological Economics*. Vol. 58 (2006); 348.
[22] Didia, Dal. "Debt-for Nature Swaps, Market Imperfections, and Policy Failures." World Development Report 1994. Oxford University Press. (1994); pp. 482.

Many economists argue that the cure for a public goods market failure is private-ownership. These forests and ecosystems affected by conservation programs often must have appropriately controlled property rights. Didia asserts that "in the aggregate, landowners will manage their land better than the government or any other institution."[23] However, if this were the case private owners would need to be subjected to strict land use regulation. Any kind of disturbance within a given area of some tropical forest could seriously affect the ecosystems that it may neighbor. Costanza, et al., contends that the smallest of disturbances may shift an ecosystem to a state that results in potentially dire social and economic consequences.[24] Accordingly, ecosystems have fairly unclear thresholds[25] in which they can take on resource depletion.[26] Unless these ecosystem thresholds can be accurately identified it will be difficult to maintain efficient resource extraction projects. Whether public land, that retains these ecosystem services, is owned by private individuals or the government should not particularly matter to those funding conservation. Either land owner type would ultimately be paid for their services, assuming a public goods cure. Efficiency, in this regard, is specifically tied to the efficient management of ecosystem resources that reside on, what is now, public land.

3.2 *Externalities*

Ecosystem services present themselves as externalities in marketable forest resource markets. Forest land provides both indirect and direct ecosystem services. Direct goods and services, such as timber, oil, minerals, agricultural uses, etc. are

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[23] Didia 483
[24] Costanza 212
[25] By using the term *threshold* we are speaking about the specific amount of resource depletion an ecosystem can assume before its benefit to society are exceeded by its cost.
[26] Id. 212

typically represented in forest product markets. Indirect ecosystem services, such as carbon sequestration (see climate regulation), soil retention, and water regulation, have less of a direct role in these resource markets. These markets for forest products often fail to consider the costs to society associated with ecosystem service loss when some of these direct goods are extracted. Many of these ecosystem services are interconnected, as stated earlier, thus the removal of one ecosystem service from an ecosystem may reduce the value of one or more other ecosystem services in that same region.

Though not the main objective of this section it is important to consider that forest products, which are marketable, are subject to the tragedy of the commons. "Tragedy of the commons" is a concept most notably considered by Garret Hardin in 1968.[27] In this essay Hardin suggests that a person seeks to increase their utility withstanding no limit, while in reality some limit certainly does exists for all goods that they may exploit.[28] This is an issue that applies to forest products as we have discussed them. These forms of capital are often removed for their marketable uses, which also removes the ecosystem services they provide. The over-harvesting of these marketable forest products results in high costs to society in the form of ecosystem services depletion. If forest products are harvested so to will be ecosystem services.

So as we consider the markets for direct good forest products (such a timber, agriculture, land, oil, etc.) it is important to understand the loss of various ecosystem services that comes with the production of these direct good forest products. Barbier and Burgess back up this idea in stating that "pricing and economic policy influencing tropical forest land use decisions rarely take into account the foregone environmental

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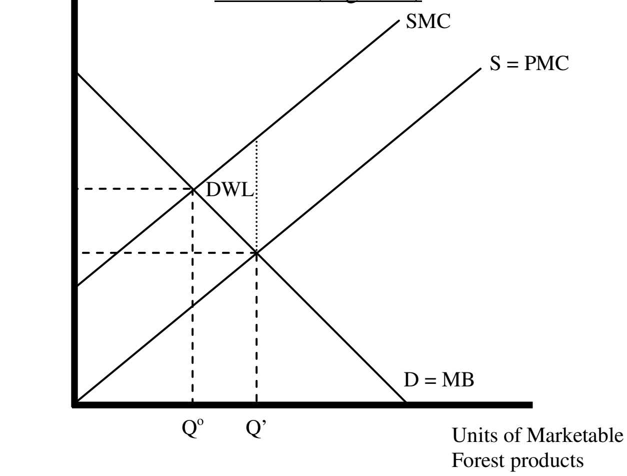
[27] Hardin, Garret. "The Tragedy of the Commons," *Science*, Vol. 162, No. 3859 (December 13, 1968), pp. 1243-1248.
[28] Id. 1244

benefits of forest conversion."[29] In short, forest products may be oversupplied due to the effect their production has on ecosystem services.

The externality model (figure 2) displays the over-allocation of resources to forest products. As can be seen, the social marginal cost (SMC) of forest resource production exceeds the supply of forest products, which equals private marginal cost (PMC). Ideally supply should be equal to social marginal cost; however that is not the case here. Where S=PMC crosses demand (D) the level of quantity produced is Q', whereas when SMC crosses demand the level of output is Q^o. The result of this over-allocation of resources towards forest products is a deadweight loss, displayed by the triangle DWL. This deadweight loss represents the loss of welfare incurred by society as a result of an over-allocation of resources.

Externality Model for Forest Products (Figure 2)



S reflects the PMC of exploiting forest products. The result is Q'. SMC is greater than PMC. If S reflected SMC the result would be Q^o. The difference between Q^o and Q' is the oversupply of forest products. DWL represents the deadweight loss to society.

For instance, commercial logging is a significant factor in deforestation within Latin America and Africa.[30] The removal of trees from an ecosystem comes with various other actions as well. For example roads must be built, which disrupts the natural process of these forests. There is also the risk of costly pollution when any kind of machinery

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[29] Barbier, E.B. and J.C. Burgess. "The Economics of Tropical Deforestation." Issues in Environmental Economics (2002); pp. 178

[30] Sierra, Rodrigo. "The Role of Domestic Timber Markets in Tropical Deforestation and Forest Degradation in Ecuador: Implications for Conservation Planning and Policy." *Ecological Economics*. Vol. 36. (2001); pp. 329.

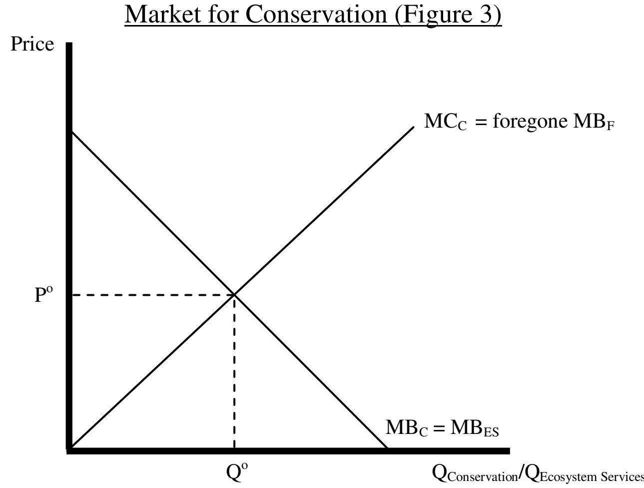
enters such a pristine environment. Run-off may negatively affect local water supply, in terms of clarity and turbidity, which in turn may disturb the lifecycles of indigenous cultures and local flora and fauna. If these actions don't result in disease or death these members of the local population may instead be forced to migrate. As indigenous peoples, and of course flora and fauna, are not members of the community market their concerns often remain unheard regarding issues of logging and other forms of forest product production. These represent just some of consequences of this oversupply of forest products.

Negative externalities such as these can be relieved through methods of conservation. It is true, though, that a certain amount of resource exploitation may be socially beneficial. This efficient amount of resource exploitation can also be looked at in a converse approach. Instead we can look at the efficient amount of tropical forest conservation (of ecosystem services).

3.3 *Optimal Conservation*

As we look at Figure 3 we are reminded of the same market in Figure 1 (pg. 6). We must remember that demand in this market does not truly exist without regulatory measures. So we consider such a market strictly in terms of the marginal cost and marginal

Market for Conservation (Figure 3)



Where MC=MB the optimum quantity of conservation/ecosystem services Q^o results. This suggests that resources are neither over nor underallocated.

benefit of conservation/ecosystem services. First of all, the aggregate benefit of all units of conservation (or each additional unit of ecosystem services conserved) makes up the curve represented by $MB_C=MB_{ES}$. This curve is downward sloping, which means that each additional unit of C or ES (conservation or ecosystem services respectively) will provide a lower benefit than the unit before it. The aggregate cost of all units of conservation/ecosystem services (which is equal to the aggregate foregone benefit of these same units) is reflected in the curve labeled MC_C=foregone MB_F. This curve is upward sloping which suggests that each additional unit of ecosystem services provides a greater cost (or foregone benefit) than that which came before it. Where these two curves intersect we can find an optimal quantity of conservation/ecosystem services, Q^o. This quantity represents the efficient allocation of resources towards conservation and ecosystem services in which these resources could have gone to no better societal enhancing use. There is no deadweight loss at this particular quantity unlike in figure 1 at Q' (pg. 6). Any other quantity of conservation and ecosystem services (ceteris paribus[31]) would result in a misallocation of resources towards these services which would then result in a deadweight loss.

It is troubling, though, that perfect information is not to our advantage in this case. Unless we can estimate the true value of ecosystem services it will be difficult to measure their absolute marginal benefit and marginal cost. The result of this could lead to an imperfect allocation of resources, in which a deadweight loss may exist.

Many public goods are difficult to quantify in terms of true economic value. For example, the air we breathe is certainly considered priceless by some; nevertheless a certain amount of pollution may be socially allowable as long as the benefits (in terms of

[31] Latin for "with all other things being equal"

resource use) exceed the costs. How do we measure these costs and benefits? As mentioned earlier, Costanza, et al., states that we evaluate such "unquantifiable" goods every day.[32]

Valuation methods for ecosystem services do in fact exist, though they are as of yet imperfect. Science has not yet caught up with society's needs. We have not yet developed the tools to evaluate all areas of the environment; claims Barbier "our current understanding of key ecological and economic relationships is sufficient to value only a handful of ecological services."[33] This typifies the information failure mentioned earlier in this section. There is certainly is hope, though, that this problem will lessen over time with technological and intellectual advancement.

Another key issue regarding the development of valuation tools for ecosystem services is the dynamic nature of their state.[34] We cannot appropriately consider their social value in a static context, which provides significant challenges. As such, models are typically very complex and, ideally, must differ from ecosystem to ecosystem. An example of such a system is currently in development at the Gund Institute for Ecological Economics at the University of Vermont.[35] Their project looks to modeling, data collection, valuation and outreach as a way of attempting to comprehend the value of natural capital throughout the planet.[36] Still, some question the ability to assess such

[32] Costanza, et al. 6
[33] Barbier 179
[34] Raghunandan, D. "Environment and Development under Capitalist Globalisation." *Social Scientist*. Vol. 31, No. 9/10. (Sep.-Oct., 2003); pp. 38
[35] For their website see http://www.uvm.edu/giee/?Page=default.html
[36] Gund Institute for Ecological Economics: University of Vermont. 2007. U of Vermont. Dec. 10, 2007 <http://www.uvm.edu/giee/?Page=default.html#introduction>

complex processes,[37] while others stress that there is continued improvement in ecosystem service valuation all of the time, though we have not reached a sufficient understanding as of yet.[38,39]

It may partially be this lack of understanding regarding the true value of ecosystem services that contributes to the aforementioned externality and public goods market failures. If more ecosystem services information becomes readily available there is the potential for an improved understanding of the monetary value they provide. Without proper action, however, the market failures list above (i.e. public goods and externalities) will remain. These market failures affect every person on this planet to some degree. Quite simply it is the job of all countries to take action in this regard. As the World Bank stated in a recent document, "global public goods concerns all countries, rich and poor, and they can no longer be separated from national interests."[40]

IV. Ecuador Case Study

Ecuador, being a largely forested country, was watching when in September 2007 a group of eight developing countries, aptly titled the Forestry Eight, became global lobbyists within issues of conservation. The Forestry Eight included the following members Brazil, Malaysia, Papua New Guinea, Gabon, Cameroon, Costa Rica, Congo

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[37] Gregory, Robin, Sarah Lichtenstein, Thomas C. Brown, George L. Peterson, Paul Slovic. "How Precise Are Monetary Representations of Environmental Improvements?" *Land Economics*. Vol. 71, No. 4. (Nov., 1995); pp. 471

[38] Deutsch, Lisa, Carl Folke, Kristin Skånberg. "The critical natural capital of ecosystem performance as insurance for human well-being." *Ecological Economics*. Vol. 44. (2003); pp. 214

[39] Barbier 213

[40] Joint Ministerial Committee of the Boards of Governors of the Bank and the Fund On the Transfer of Real Resources to Developing Countries. Global Public Goods: A Framework for the Role of the World Bank. Sept. 28, 2007. November 11, 2007. <http://siteresources.worldbank.org/DEVCOMMINT/Documentation/21510685/DC2007-0020(E)GlobalPublicGoods.pdf>.

and Indonesia.[41] These countries alone make up for 80% of the tropical rainforests in the world.[42] This group set out to demand that developed countries compensate developing countries for the conservation of their tropical rainforests as part of new greenhouse reduction standards. In the run up to the Kyoto talks in Bali in December 2007 Indonesia and this Forestry group began to recruit other rainforest countries into their coalition, including Ecuador. Global warming is certainly one of this generation's most significant political hot-buttons. This method of compensation for conservation has the potential to gather wide-spread support as conservation can often come cheaper than reducing carbon emissions. This is useful because as Boyland points out "forests have the potential to sequester and store carbon that otherwise would be in the atmosphere contributing to global warming."[43] In November of 2007 Ecuador President Rafael Correa publicly announced Ecuador's support for this group and their cause.[44]

Throughout the 20th century Ecuador's demand for cultivated land and pasture resulted in nearly 90% of the deforestation in the country, though it should be noted that much of this area had already been harvested for timber.[45] Migrant agricultural farmers are also to blame for much of the deforestation within the Amazon basin of Ecuador.[46] In an empirical study Didia suggests that debt and deforestation are, statistically, positively

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[41] Aglionby John and Fiona Harvey. "Forest Nations Press for Carbon Credits to Help Cut Greenhouse Gas." Financial Times (Sept. 13, 2007): Oct. 24, 2007. <http://search.ft.com/ftArticle?queryText=forest+nations+press+for+carbon+credits&y=0&aje=true&x=0&id=070913001353&ct=0>.

[42] Ibid

[43] Boyland, Mark. "The Economics of Using Forests to Increase Carbon Storage." *Canadian Journal of Forest Research*. Vol. 36, No. 9 (Sept. 2006); 2232

[44] Pathoni, Ahmad. "Ecuador Backs Indonesia Bid for Forest Compensation." Reuters UK (Nov. 26, 2007): Dec. 06, 2007. <http://uk.reuters.com/article/environmentNews/idUKJAK23478720071126>.

[45] Wunder, Sven. "Ecuador Goes Bananas; Incremental Technological Change and Forest Loss." *Agricultural Technologies and Tropical Deforestation*. (2001); pp. 168.

[46] Pinchón, Francisco J. "Colonist Land-Allocation Decisions, Land Use, and Deforestation in the Ecuadorian Amazon Frontier." *Economic Development and Cultural Change.* Vol. 45, No. 4. (July 1997); pp. 737.

and significantly related.[47] Ecuador ranks as number seventy-one in the world in public-debt at thirty-three percent of their GDP (as of 2006).[48]

In 2005 Ecuador was ranked 142nd in the world in GDP per capita[49] (at $4500 US), thus suggesting a high level of poverty within its borders. Government action to prevent poverty and devoting resources to promote conservation seems to be conflicting goals. Though conservation and ecosystem service preservation carry great benefit, the prevention of global warming and resource preservation, etc. will not be immediately noticeable. That is why conservation remains to be an action that specifically considers long-term repercussions. However, poverty brings with it short-term difficulties. Ehrhardt-Martinez suggests that deforestation and rural poverty have a well established relationship.[50] This often results in ecosystem encroachment in the form of general settling and/or slash-and-burn techniques (which in itself adds to greenhouse gases). Poverty also creates an immediate demand for economic security. This pressing obligation certainly leads to higher rates of resource depletion which is the case in Ecuador.

The land within the ITT Block, residing right in the heart of the Yasuní National Park on the eastern reaches of the Amazon Forest, holds one of the largest remaining oil reserves in the world, an estimated 1.5 billion barrels of oil.[51] These oil reserves are directly in the middle of one of the richest ecosystems on the planet. In fact, Sierra

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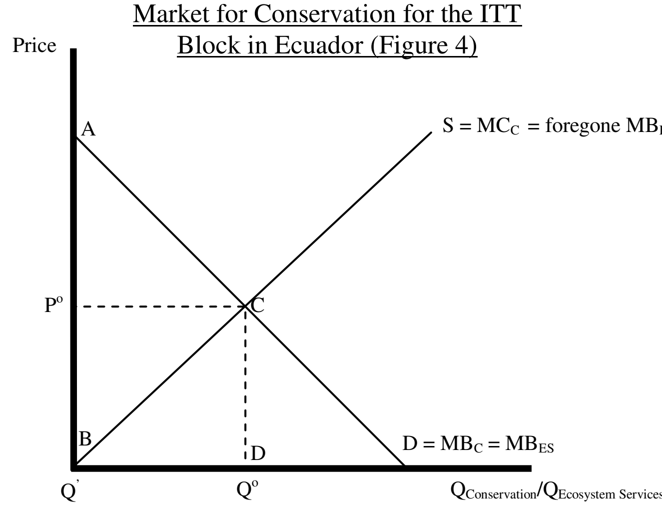
[47] Didia 481
[48] "Rank Order-Public Debt." CIA - The World Factbook. Dec. 13, 2007. The World Factbook. Dec. 13, 2007 < https://www.cia.gov/library/publications/the-world-factbook/rankorder/2186rank.html>.
[49] "Rank Order - GDP - per capita (PPP)." CIA - The World Factbook. Dec. 13, 2007. The World Factbook. Dec. 13, 2007 < https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.htmll>.
[50] Ehrhardt-Martinez, Karen. "Social Determinants of Deforestation Developing Countries: A Cross-National Study." *Social Forces*. Vol. 77, No. 2. (Dec., 1998); pp. 573
[51] "Ecuador Studies Venezuela Offer on ITT Oil Project." Reuters UK (Apr. 18, 2007): Oct. 17, 2007. <http://uk.reuters.com/article/oilRpt/idUKN1830788420070418>

reveals that "this region has been considered one of the 'hot spots' of the world; areas with high and unique biodiversity but where environmental degradation is occurring at a fast pace."[52]

President Correa's demands for compensation to conserve the ITT Block were fairly significant, but economically commendable, demanding one half of Ecuador's foregone benefit (in terms of lost oil revenue, development, etc.) associated with conserving this area. Indeed, if we were to look at the market for conservation/ecosystem services we would consider that for every unit of conservation, those who have the rights to these forests (the Ecuadorian Government) incur some level of foregone benefit.

Market for Conservation for the ITT Block in Ecuador (Figure 4)



Where S=MC=MB=foregone MB_F we end up with the optimum quantity Q^o. Without any form of demand the current quantity level is at Q'. The DWL is reflected by triangle ABC and the foregone benefit is reflected by area BCD.

Figure 4 signifies the market for conservation/ecosystem services within the ITT Block in the Amazon Forest of Ecuador. Do to the lack of demand, as discussed in 3.1, there is a deadweight loss represented by triangle ABC. Conversely, if the methods of conservation mentioned earlier were to allow for the optimal quantity of conservation, Q^o, triangle ABC would correspond to the social welfare gain associated with this efficient allocation of resources towards conservation. Accordingly the area denoted by triangle BCD represents the area associated with the forgone marginal benefit that results from this reallocation of resources.

[52] Sierra 330

When President Correa suggests compensation up to half the point of Ecuador's foregone benefit associated with conservation it is likely he is considering the area mentioned above (BECD), or at least one-half of it. Granted it should be considered that perhaps some of this foregone marginal benefit is distributed beyond the borders of Ecuador[53]. Nevertheless, it is reasonable to state that much of it would directly affect the forest's home country. The reasons for this include immediate ecosystem service benefit, not available beyond borders, such as water regulation, soil retention, etc. It is somewhat curious however that Ecuador would not ask the market price, P^o, at the optimum quantity level. However, it may be that this is merely a political move needed in order to ensure the success of such a program.

In November of 2007 President Correa decided to cancel plans for oil exploitation in the ITT Block.[54] This came days after an environmental workshop took place in Quito, the capital of Ecuador, in which plans for compensation were laid out. The governments of Spain, Italy, and Norway as well as philanthropists from the United States planned to contribute to this compensation fund.[55]

Accordingly, it is of little surprise that President Correa is backing calls for forest compensation on the behalf of developed countries for those in the developing world, such as Ecuador. Though as of this paper's completion the results of the Bali talks are not yet known it is clear that this movement is picking up steam as a way of preventing climate change. It must be acknowledged that all ecosystem services in this particular conservation scheme do not seem to be completely acknowledged. This is because the

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[53] For example, consumers of gasoline forgo cheaper gas, which would have been the result of oil extraction. In return these consumers receive the benefits of the ecosystem services protected.
[54] Guodong, Du. "Ecuador Cancels Oil Exploitation in Amazon." China View (Nov. 24, 2007): Dec. 12, 2007. <http://news.xinhuanet.com/english/2007-11/24/content_7136457.htm>
[55] Id

focus here is on carbon sequestration, in regards to global warming. So these tropical forest ecosystems may be undervalued to some extent. Still, this provides a necessary step in preventing costly ecosystem service loss throughout the world.

There are various difficulties in regards to compensating these developing countries. For example, any investment in conservation by a developed nation requires some long-term assurance of the ecosystem's viability. It cannot be expected that in a less-than-perfectly stable country large initial funds will guarantee conservation if by chance the government were to be dissolved. Therefore, there is a need for methods in which compensation is developed in a manner that allows for year-to-year assurance. There are various methods where compensation can be developed, as will be discussed in the next section.

V. Policy Suggestions

5.1 Basic Approach

Generally market-based projects work better within countries that are market-based economies. The uncertain property right characteristics and instability of non-market economies provides little assurance in the way of natural resource management. Didia suggests that democracies provide checks and balances which, in turn, enable more sustainable exploitation of natural resources.[56] Though the type of government is not under question stability, as far as resource management is concerned, is. Due to potential complexities related to the issues suggested it is important to consider the situation of a developing country before entering talks to compensate them for the conservation of an ecosystem.

[56] Didia 482

Ferraro claims that "performance payments (compensation) create incentives for local residents to have an active stake in protecting ecosystems."[57] As such, compensation can be given to land owners or the government, whoever manages the property rights of the targeted tropical forest. Transaction costs may be less when dealing with one larger manager, but property right situations depends upon the countries in question and their laws. Regardless of the property manager it is still likely that without compensation these land owners will direct resources towards the next best thing (i.e. tropical forest resource exploitation).

5.2 Specific Policy Suggestions

Investing in poverty reduction programs may hit right at the core of this entire situation. If poverty is one of the key reasons for deforestation, as mentioned earlier, then such a method of investment would compensate while at the same time relieve some of the direct pressures being put on the forests themselves. This is an idea that would require country and region-specific implementation. In the end this could be utilized as a partial solution within a larger compensatory package.

Over the last couple of decades debt-for-nature swaps have grown into a common practice in the world of conservation. According to Sheeran the partial debt-relief offered by these debt-for-nature swaps is a profound example of the willingness and ability of developed countries to pay for the ecosystem services within developing countries.[58] Didia suggests, however, that due to the high demand for fuelwood and foreign exchange,

[57] Ferraro, Paul J. "Global Habitat Protection: Limitations of Development Interventions and a Role for Conservation Performance Payments." *Conservation Biology*. Vol. 15, No. 4. (Aug. 2001); pp. 998.
[58] Sheeran 348

we cannot depend on debt-for-nature swaps to completely relieve deforestation rates.[59] Demand for this tactic would change if the free-riding issue was resolved, making the demand for fuelwood and foreign exchange a somewhat irrelevant issue. Other reasons for this tend to focus on the political instability of the compensated country. Specifically, Dauvergne points out that "institutionalized corruption and a centralized military leadership make (debt-for-nature swaps) unrealistic."[60] Debt-for-Nature swaps, as a result, should not be seen as a be-all-end-all solution to deforestation but they certainly could play a role in a larger picture of compensation.

Another option for compensation could be the ability for a developing country to receive special drawing rights from the International Monetary Fund (IMF). Special drawing rights were originally used to support stability during the Bretton Woods Fixed Exchange Rate system, which ended in 1973. The fund today is in part used as an exchangeable reserve asset. This would provide these countries with increased liquidity allowing easier exchange throughout the world. The objective of this would be the stimulation of the economy of the developing countries involved. This is, of course, assuming the capable nature of the government and economic system within the developing country. There may be less interest in this program from developing countries if it is estimated that the short-run effect is too little. However this as well could be part of a larger compensatory package.

Furthermore, if a global emissions market comes to fruition the allocation of carbon credits could become a potential method for compensation as well. Carbon

[59] Didia 482
[60] Dauvergne, Peter. "The Politics of Deforestation in Indonesia." *Pacific Affairs*, Vol. 66, No. 4. (Winter, 1993-1994); pp. 518.

credits are permits that allow for a certain level of carbon dioxide to be emitted. In trading a potential commodity like this, those who are most willing and able to pay for them would have the opportunity. Interestingly, while developing countries, such as Ecuador, may not be able to conserve given other immediate needs, they can exchange land use rights (hypothetically for conservation) for such commodities like carbon credits. These credits can boost their economy in industrial areas, generally relieving some of the pressures related to the need for ecosystem destruction through resource depletion. Such a process would allow a developing country to meet global standards in emissions while remaining able to compete in the global economy. Carbon credits could provide these countries an opportunity to become competitive while remaining economically sustainable.

5.3 Sustainability Methods and Accountability

Any kind of packaged deal for compensation must be approached with long-run sustainability in mind. Paying a large chunk of money to a developing country does not necessarily decrease the risk of future deforestation. It is therefore important to ensure payments remain at a long-term level. With the instability of government within many developing countries it should be a priority to have strict enforcement of any such agreement. A government should not be able to break a deal simply to acquire the short-term benefits of deforestation. Any compensation deal must be made in such a way that both sides of the contract are held accountable for their actions in a specifically determined period of time. This deal must also take into account a reasonable discount rate. A lower discount rate will likely receive greater support of the developing country as it would suggest greater future value of an ecosystem. However it is important to choose a responsible discount rate that benefits both sides.

This concept of accountability is quite important in regards to all sorts of contracts. International contracts require international enforcement. Consequently, it is necessary that an international organization is borne or transformed to accommodate such contracts. They must have the power necessary to enforce promised action. Perhaps a spin-of of the IMF or World Bank would suffice, or maybe a new branch of the United Nations. Whatever the answer, a powerful group must be created in order to enforce either side of such compensation contracts. Without enforcement, the value of these contracts could be limited to nothing.

In the situation suggested above, ecosystems are more or less rented for their ecosystem service output. On the other hand, land on which tropical forests reside could potentially be fully marketable. Perhaps an international organization, or national government, would have the opportunity to purchase the rights to some tropical forest. This could provide the opportunity to ensure long-run conservation. While there may be the possibility of land sales for conservation it is unlikely to occur, at least at a high rate. The reason for this is sovereignty issues, in which many countries are unlikely to give up a portion of their territory. Also, any country or organization that may buy land may have the opportunity to also demand compensation, which would lead us back to the same position as that of "renting" tropical forests.

Before pursuing every tropical forest it is absolutely vital to consider political will and resources. It is likely that it is not yet politically feasible to take on every country that produces international ecosystem services. Therefore much initial work should go into deciding which areas are in the most need of critical protection. These areas will tend to be those often referred to as "hot spots."[61]

VI. Conclusion

Ecosystems provide a wide array of benefits to society in the form of ecosystem services. Together these services form the basis for natural capital which supports much of life itself. Carrying the traits of public goods these ecosystem services are subject to free-riding. However methods of compensation for conservation would result in a demand for ecosystem services (which is now practically non-existent) that would reflect something much closer to the true marginal benefit for society.

The externalities in the forest products (marketable products associated with the exploitation of tropical forests) market may be directly related to the public goods issue. Demand for conservation/ecosystem services should increase via governmental action. If this is the case then it is likely that those resources that are indeed extracted from tropical forests will then come from ecosystems of less societal value than those that are conserved. This is assuming that information is readily available for comparing the true value of ecosystem services within different areas of tropical forests.

It is absolutely critical that information continues to improve regarding the value of ecosystem services. This indeed does seem to be the trend; however it is important that more investment is put into the understanding of these critical and integral assets of our society and economy. Once the valuation methods begin to reflect the true worth of ecosystem services it is likely that we will begin to see an appropriate allocation of resources towards conservation.

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[61] See definition of hot spots in section IV.

When considering the value of ecosystems it should be noted that no two areas are identical. Therefore great care must be placed in the valuation of such capital assets, as every relationship within an environment is reflected in some form of natural capital. Cost-benefit analysis should be undertaken within each prominent ecosystem in order to determine the optimal level of conservation.

It should also be worthwhile to accept that not every problem has a simple solution. The conservation of one ecosystem does not imply the conservation of another. Areas are different, the benefits and costs are different, and politics are different. Focus should remain on areas of which society receives the greatest benefit. If the value provided by ecosystem services becomes readily comprehensible, perhaps someday these services will be become viable commodities in the world's economy. Carbon credits represent this potential to some extent today, as they are tradable in return for promises of conservation.

The world is heading towards a time in which conservation in developing countries is compensated by developed countries. In fact the World Bank has devoted $160 million toward a Forest Carbon Partnership facility.[62] Ecosystem services are vastly misunderstood and carry many traits that have lead to the market failures in conservation and forest product markets we see today. Our economy is greatly dependent on many of the services provided by tropical forests. With more information regarding the value of ecosystem services to society and a stronger role taken by government, or some supranational organization, in compensatory measures we can protect much of the

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[62] Greising, David. "Nations Take a Singular Stand, to Save Standing Rain Forests." Chicago Tribune. (Dec. 18, 2007): Dec. 16, 2007. <www.chicagotribune.com/news/nationworld/chi-credits_greisingdec18,1,2633388.story>

economically-beneficial services provided by tropical forests around the world.

Appendix 1 [63]

Function		Ecosystem Infrastructure and Processes	Goods and Services (examples)
Regulation Functions *Maintenance of essential ecological processes and life support systems*			
1	Gas regulation	Role of ecosystems in biogeochemical cycles	Provides clean, breathable air, disease prevention, and a habitable planet
2	Climate regulation	Influence of land cover and biological mediated processes on climate	Maintenance of a favorable climate promotes human health, crop productivity, recreation, and other services
3	Disturbance prevention	Influence of ecosystem structure on dampening environmental disturbances	Prevents and mitigates natural hazards and natural events, generally associated with storms and other severe weather
4	Water regulation	Role of land cover in regulating runoff and river discharge	Provides natural irrigation, drainage, channel flow regulation, and navigable transportation
5	Water supply	Filtering, retention and storage of fresh water (e.g. in aquifers and snow pack)	Provision of water for consumptive use, includes both quality & quantity
6	Soil retention	Role of vegetation root matrix and soil biota in soil retention	Maintains arable land and prevents damage from erosion, and promotes agricultural productivity
7	Soil formation	Weathering of rock, accumulation of organic matter	Promotes agricultural productivity, and the integrity of natural ecosystems
8	Nutrient regulation	Role of biota in storage and recycling of nutrients	Promotes health and productive soils, and gas, climate, and water regulations
9	Waste treatment	Role of vegetation & biota in removal or breakdown of xenic nutrients and compounds	Pollution control/ detoxification; Filtering of dust particles through canopy services
10	Pollination	Role of biota in movement of floral gametes	Pollination of wild plant species and harvested crops
11	Biological control	Population control through trophic-dynamic relations	Provides pest and disease control, reduces crop damage
Habitat Functions *Providing habitat (suitable living space) for wild plant and animal species*			
12	Refugium function	Suitable living space for wild plants and animals	Maintenance of biological and genetic diversity (and thus the basis for most other functions)
13	Nursery function	Suitable reproduction habitat	Maintenance of commercially harvested species

[63] Asia Pacific Environmental Exchange. Ecosystem Services Enhanced by Salmon Habitat Conservation in the Green/Duwamish and Central Puget Sound Watershed. Seattle, WA: Asia Pacific Environmental Exchange. (February 2005); pp. 10-11

Production Functions *Provision of Natural Resources*			
14	Food	Conversion of solar energy into edible plants and animals	Hunting, gathering of fish, game, fruits, etc.; small scale subsistence farming & aquaculture
15	Raw materials	Conversion of solar energy into biomass for human construction and other uses	Building and manufacturing; fuel and energy; fodder and fertilizer
16	Genetic resources	Genetic material and evolution in wild plants and animals	Improve crop resistance to pathogens & pests
17	Medicinal resources	Variety in (bio)chemical substances in, and other medicinal uses of, natural biota	Drugs, pharmaceuticals, chemical models, tools, test and essay organisms
18	Ornamental resources	Variety of biota in natural ecosystems with (potential) ornamental use	Resources for fashion, handicraft, jewelry, pets, worship, decoration & souvenirs
Information Functions *Providing opportunities for cognitive development*			
19	Aesthetic information	Attractive landscape features	Enjoyment of scenery
20	Recreation	Variety in landscapes with (potential) recreational uses	Travel to natural ecosystems for ecotourism, outdoor sports, etc.
21	Cultural and artistic information	Variety in natural features with cultural and artistic value	Use of nature as motive in books, film, painting, folklore, national symbols, architecture, advertising, etc.
22	Spiritual and historic information	Variety in natural features with spiritual and historic value	Use of nature for religious or historic purposes (i.e., heritage value of natural ecosystems and features)
23	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions, etc. Use of nature for scientific research

Work Cited

Aglionby John and Fiona Harvey. "Forest Nations Press for Carbon Credits to Help Cut Greenhouse Gas." Financial Times (Sept. 13, 2007): Oct. 24, 2007. <http://search.ft.com/ftArticle?queryText=forest+nations+press+for+carbon+credits&y=0&aje=true&x=0&id=070913001353&ct=0>.

Asia Pacific Environmental Exchange. Ecosystem Services Enhanced by Salmon Habitat Conservation in the Green/Duwamish and Central Puget Sound Watershed. Seattle, WA: Asia Pacific Environmental Exchange. (February 2005); pp. 10-11

Barbier, Edward B. "Valuing Ecosystem Services." *Economic Policy*. (January 2007); pp. 176-229

Barbier, E.B. and J.C. Burgess. "The Economics of Tropical Deforestation." Issues in Environmental Economics ed. Nick Hanley and Colin J. Roberts (2002); pp. 163-183

Boyland, Mark. "The Economics of Using Forests to Increase Carbon Storage." *Canadian Journal of Forest Research*. Vol. 36, No. 9 (Sept. 2006); 2223-2234

Brown, Stephen N., David Price and Satish Raichur. "Public-Good Theory and Bargaining between Large and Small Countries." *International Studies Quarterly*. Vol. 20, No. 3 (September 1976); pp. 393-414

"Carbon Sequestration in Agriculture and Forestry." US EPA. October 19, 2006. United States Environmental Protection Agency. November 15, 2007 <http://www.epa.gov/sequestration/index.html>.

Costanza, Robert, et al. "The Value of the World's Ecosystem Services and Natural Capital," *Ecological Economics*. Vol. 25, No. 1 (April 1998); pp. 3-15

Costanza, Robert, David Stern, Brendan Fisher, Lining He and Chunbo Ma. "Influential Publications in Ecological Economics; A Citation Analysis." *Ecological Economics*. Vol. 50, No. 3 (October 2004); pp. 261-292

Dauvergne, Peter. "The Politics of Deforestation in Indonesia." *Pacific Affairs*, Vol. 66, No. 4. (Winter, 1993-1994); pp. 497-518.

Deutsch, Lisa, Carl Folke, Kristin Skånberg. "The critical natural capital of ecosystem performance as insurance for human well-being." *Ecological Economics*. Vol. 44. (2003); pp. 205-217

Didia, Dal. "Debt-for Nature Swaps, Market Imperfections, and Policy Failures." World Development Report 1994. Oxford University Press. (1994); pp. 478-486.

"Ecuador Studies Venezuela Offer on ITT Oil Project." Reuters UK (Apr. 18, 2007): Oct. 17, 2007. <http://uk.reuters.com/article/oilRpt/idUKN1830788420070418>

Ehrhardt-Martinez, Karen. "Social Determinants of Deforestation in Developing Countries: A Cross-National Study." *Social Forces*. Vol. 22, No. 2. (Dec. 1998); pp. 567-586

Ferraro, Paul J. "Global Habitat Protection: Limitations of Development Interventions and a Role for Conservation Performance Payments." *Conservation Biology*. Vol. 15, No. 4. (Aug. 2001); pp. 990-1000

Gregory, Robin, Sarah Lichtenstein, Thomas C. Brown, George L. Peterson, Paul Slovic. "How Precise Are Monetary Representations of Environmental Improvements?" *Land Economics*. Vol. 71, No. 4. (Nov., 1995); pp. 462-473

Greising, David. "Nations Take a Singular Stand, to Save Standing Rain Forests." Chicago Tribune. (Dec. 18, 2007): Dec. 16, 2007. <www.chicagotribune.com/news/nationworld/chi-credits_greisingdec18,1,2633388.story>

Gund Institute for Ecological Economics: University of Vermont. 2007. U of Vermont. Dec. 10, 2007 <http://www.uvm.edu/giee/?Page=default.html#introduction>

Guodong, Du. "Ecuador Cancels Oil Exploitation in Amazon." China View (Nov. 24, 2007): Dec. 12, 2007. <http://news.xinhuanet.com/english/2007-11/24/content_7136457.htm>

Hardin, Garret. "The Tragedy of the Commons," *Science*. Vol. 162, No. 3859 (December 13, 1968), pp. 1243-1248.

Joint Ministerial Committee of the Boards of Governors of the Bank and the Fund On the Transfer of Real Resources to Developing Countries. Global Public Goods: A Framework for the Role of the World Bank. Sept. 28, 2007. November 11, 2007. <http://siteresources.worldbank.org/DEVCOMMINT/Documentation/21510685/DC2007-0020(E)GlobalPublicGoods.pdf>.

Kahn, J.R., and J. McDonald. "Third World Debt and Tropical Deforestation." *Ecological Economics*. Vol.12 (1995); 107-123

Kaiser, Brooks and James Roumasset. "Valuing Indirect Ecosystem Services; The Case of Tropical Watersheds." *Environment and Development Economics*. Vol. 7, No. 4 (October 2002), pp. 701-714

Nahuelhual, Laura, Pablo Donoso, Antonio Lara, Daisy Núñez, Carlos Oyarzún and Eduardo Neira "Valuing Ecosystem Services of Chilean Temperate Rainforests," *Environment, Development and Sustainability*. Vol. 9, No. 4 (November 2007), pp. 481-499

Nunn, Geoffrey E. and Thayer H. Watkins. "Public Goods Games." *Southern Economic Journal*. Vol. 45, No. 2. (Oct., 1978); pp. 598-606

Olschewski, Roland, Pablo C. Benítez, G.H.H. de Koning, and Tomás Schlichter. "How attractive are forest carbon sinks? Economic insights into supply and demand of Certified Emission Reductions." *Journal of Forest Economics*. Vol. 11 (2005); 77-94.

Pathoni, Ahmad. "Ecuador Backs Indonesia Bid for Forest Compensation." Reuters UK (Nov. 26, 2007): Dec. 06, 2007. <http://uk.reuters.com/article/environmentNews/idUKJAK23478720071126>.

Pinchón, Francisco J. "Colonist Land-Allocation Decisions, Land Use, and Deforestation in the Ecuadorian Amazon Frontier." *Economic Development and Cultural Change.* Vol. 45, No. 4. (July 1997); pp. 707-744.

Raghunandan, D. "Environment and Development under Capitalist Globalisation." *Social Scientist*. Vol. 31, No. 9/10. (Sep.-Oct., 2003); pp. 36-57

"Rank Order-Public Debt." CIA - The World Factbook. Dec. 13, 2007. The World Factbook. Dec. 13, 2007 <https://www.cia.gov/library/publications/the-world-factbook/rankorder/2186rank.html>.

"Rank Order - GDP - per capita (PPP)." CIA - The World Factbook. Dec. 13, 2007. The World Factbook. Dec. 13, 2007 < https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.htmll>.

Sheeran, Kristin A. "Forest Conservation in the Phillippines: A Cost-Effective Approach to Mitigating Climate Change?" *Ecological Economics*. Vol. 58 (2006); 338-349.

Sierra, Rodrigo. "The Role of Domestic Timber Markets in Tropical Deforestation and Forest Degradation in Ecuador: Implications for Conservation Planning and Policy." *Ecological Economics*. Vol. 36. (2001); pp. 327-340.

"Special Drawing Rights: A Factsheet." IMF. August 2006. International Monetary Fund. 16 Nov. 2007 <http://www.imf.org/external/np/exr/facts/sdr.htm>

Voinov, Alexey and Joshua Farley. "Reconciling Sustainability, Systems Theory and Discounting." *Ecological Economics*, Vol. 63, No. 1 (June 2007), pp. 104-113

Wunder, Sven. "Ecuador Goes Bananas; Incremental Technological Change and Forest Loss." *Agricultural Technologies and Tropical Deforestation*. (2001); pp. 167-194.